SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

5

      Be it known that I, Benjamin J. Parker, with residence and citizenship listed below, have invented the inventions described in the following specification entitled:

10   **COMMUNICATION MEDIA SIMULATION FOR A SERVICE PROVIDER**

Benjamin J. Parker

15   Residence: 9212 W. 100th St., Overland Park, Kansas 66212

       Citizenship: United States of America

COMMUNICATION MEDIA SIMULATION FOR A SERVICE PROVIDER

RELATED APPLICATIONS

Not applicable

5

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable

MICROFICHE APPENDIX

10   Not applicable

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The invention is related to the field of communication systems, and in

15   particular, to providing a simulation of a length of communication media to a

service provider.

2. DESCRIPTION OF THE PRIOR ART

High-bandwidth communications are becoming customary for both

20   businesses and residences. Customers are requesting more bandwidth from

service providers to satisfy their communication needs. Thus, service providers

are continually searching for methods and systems to supply the higher

bandwidths to their customers.

Many customers are connected to a service provider with copper wiring.

25   The portion of the public network between the phone company and the customer

is referred to as the local loop or the "last mile". The local loop often creates

bottlenecks for service providers to provide high bandwidth to its customers.

One way to overcome the bottleneck of the local loop is to transmit data over a

high frequency signal. One example of a service that transmits data over a high

30   frequency signal is Digital Subscriber Line (DSL) service.

One problem is the high frequency signals can be more susceptible to distortion from conditions existing on the local loop. The distance from the service provider can affect a high-frequency signal more significantly than a low frequency signal. Unterminated bridge taps can adversely affect a high

5   frequency signal while not significantly affecting a low frequency signal. A bridge tap is any unterminated portion of a loop not in the direct talking path. Bridge taps are often connected to a length of wire where the wire is not terminated. The unterminated wire, also called the unterminated bridge tap, can act as a tuning stub to high frequency signals. Therefore, unterminated bridge taps and

10   other conditions can affect some types of service. For example, all loading coils and bridge taps should be removed from copper cabling in a local loop before DSL services can be provided. Therefore, service providers may find it advantageous to simulate certain conditions that may affect service.

The use of high-bandwidth technology is often aided by modeling and

15   simulating the local loop. Without the ability to simulate the local loop and a customer premises, service providers may miss opportunities to access potential customers. Also, service providers may not have a cost effective way to determine a quality of service (QoS) for current or potential customers.

Service providers currently use simulators that simulate conditions that

20   could affect communications from the service provider over the local loop. The simulators are generally fixed circuits that apply a load to service provider signals to simulate the effects of customer premises devices, wire lines, bridge taps, and other conditions. Fixed circuits mean that the components that make up the circuits have fixed values. For instance, a resistor has a fixed resistance, an

25   inductor has a fixed inductance, and a capacitor has a fixed capacitance. This is in contrast to variable components. Variable components are components that can be tuned to accommodate different needs. Examples of variable components are variable resistors, variable inductors, and variable capacitors.

Each simulator is a separate circuit with the current systems. For

30   instance, the customer premises device simulator, the wire line simulator, and the bridge tap simulator are all separate circuits. These separate circuits are

connected to simulate multiple configurations. If the service provider wants to simulate a complex configuration, then many different circuits have to be connected together. Unfortunately, the multiple circuits and multiple connections can become cumbersome and undesired for the service provider.

5   The current wire line simulators are fixed circuits that simulate a fixed length of wire. For instance, a wire line simulator could simulate 1,000 feet of copper wire. Multiple wire line simulators are connected in series to simulate longer lengths of wire. Also, bridge tap simulators are fixed circuits that simulate a fixed length of wire connected to a bridge tap. Unfortunately, the fixed-circuit

10   simulators can only approximate conditions of a local loop. The fixed-circuit simulators are not tunable and consequently may not be able to simulate conditions that service providers desire.

SUMMARY OF THE INVENTION

15   The invention helps to solve the above problems with an improved system and method of simulating a length of communication media to a service provider. The invention advantageously provides a highly versatile and cost effective way of simulating a length of communication media. The invention also gives a service provider more flexibility as to the types of conditions that can be

20   simulated.

       One example of the invention includes a simulation system. The simulation system is comprised of a communication media simulator system. The communication media simulator system is comprised of an interface system and a tunable simulator system. The interface system communicates with a

25   service provider communication link of a service provider. The tunable simulator system receives a service provider signal from the interface system. The tunable simulator system applies a first load to the service provider signal to simulate a length of communication media. The tunable simulator system varies the first load to adjust the length of communication media simulated.

30   In another example of the invention, the simulation system is housed in a single enclosure. The simulation system advantageously exists in a single

enclosure to help avoid cumbersome and confusing connections between multiple circuits.

In another example of the invention, the communication media simulator system also includes a noise simulator system. The noise simulator system is

5 configured to generate a noise signal and apply the noise signal to the service provider signal to simulate noise interference. The noise simulator system varies the noise signal to adjust the noise interference simulated. The noise signal varies to represent both near-end cross talk and far-end cross talk.

In another example of the invention, the communication media simulator

10 system also includes a bridge tap simulator. The bridge tap simulator is configured to apply a second load to the service provider signal to simulate an unterminated bridge tap. The bridge tap simulator varies the second load to simulate a variable length of wire connected to the bridge tap.

In another example of the invention, the simulator system also includes an

15 output system. The output system determines simulation results by measuring signals at different locations within the simulation system. The output system then transmits the simulation results to a user interface. The user interface could be a display on the output system, an auxiliary computer, or some other user interface.

20 In another example of the invention, the simulation system also includes a control system. The control system automatically adjusts the tunable simulator system, the noise simulator system, or the bridge tap simulator to simulate certain conditions for a particular simulation.

25 BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram that illustrates a simulation system in the prior art.

FIG. 2 is a circuit diagram that illustrates the simulator system in FIG. 1 in the prior art.

30 FIG. 3 is a block diagram that illustrates a simulation system in an example of the invention.

FIG. 4 is a flow diagram that illustrates a process executed by the simulation system in FIG. 3 in an example of the invention.

FIG. 5 is a circuit diagram that illustrates a wire line simulator in an example of the invention.

5 　　　　FIG. 6 is a circuit diagram that illustrates a bridge tap simulator in an example of the invention.

FIG. 7 is a circuit diagram that illustrates a noise simulator system in an example of the invention.

10 DETAILED DESCRIPTION OF THE INVENTION

Prior Art Simulator -- FIGS. 1-2

To better understand the invention, FIGS. 1-2 are provided to show the current state of the art. FIG. 1 depicts a simulation system 102 connected to a service provider 104 in the prior art. The simulation system 102 is comprised of 15 a fixed-length wire line simulator 112, a bridge tap simulator 114, and a telephone simulator 116. Fixed-length wire line simulator 112 is comprised of a fixed-length wire line load 122. Bridge tap simulator 114 is comprised of a bridge tap load 124. Telephone simulator 116 is comprised of a telephone load 126. Fixed-length wire line load 122, bridge tap load 124, and telephone load 126 are 20 separate circuits. Fixed-length wire line load 122, bridge tap load 124, and telephone load 126 could be housed in separate enclosures.

In operation, service provider 104 transmits a service provider signal. Fixed-length wire line simulator 112 applies fixed-length wire line load 122 to the service provider signal to simulate a fixed-length of wire. Bridge tap simulator 25 114 applies bridge tap load 124 to the service provider signal to simulate an unterminated bridge tap. Telephone simulator 116 applies telephone load 126 to the service provider signal to simulate an off-hook condition or an on-hook condition of a telephone.

FIG. 2 depicts a circuit diagram of fixed-length wire line load 122, bridge 30 tap load 124, and telephone load 126. Fixed-length wire line load 122 is comprised of resisters 211-213, inductors 221-222, and a capacitor 231.

Resister 211 and inductor 221 connect in series to a node 261. Nodes 261-264 are referred to in FIG. 2 by arrows for illustrative purposes and those skilled in the art will appreciate that nodes 261-264 are defined by Kirchhoff's Law. Resister 212 and inductor 222 connect in series to node 262. Resistor 213

5   connects in parallel to node 261 and node 262. Capacitor 231 also connects in parallel to node 261 and node 262.

Bridge tap load 124 is comprised of resisters 214-217, inductors 223-224, a capacitor 232, and switches 241-242. Resister 214 and inductor 223 connect in series to switch 242 and node 263. Resister 215 and inductor 224 connect in

10   series to switch 242 and node 264. Resister 216 and capacitor 232 each connect in parallel between nodes 263-264. Switch 241 connects to nodes 263 and 264. Switch 242 connects to resistor 217 via connections 273 and 274. Switch 241 also connects to nodes 261 and 262 of fixed-length wire line load 122.

15   Telephone load 126 is comprised of capacitors 233-234, a switch 243, and resistors 218-219. Switch 243 connects to switch 242 of bridge tap load 124 via connections 275 and 276. Switch 243 connects to capacitor 233 via connections 277 and 278. Switch 243 connects to resistor 218 via connection 279. Resistor 218 connects in series to capacitor 234. Capacitor 234 connects

20   in series to resistor 219. Switch 243 connects to resistor 219 via connection 280.

Fixed-length wire line load 122 simulates a fixed-length of wire to service provider 104. For example, fixed-length wire line load 122 could simulate 1000 feet of copper wire. Switch 241 of bridge tap load 124 controls whether to apply bridge tap load 124 to simulate an unterminated bridge tap condition. Like fixed-

25   length wire line load 122, bridge tap load 124 simulates a fixed length of wire connected to a bridge tap. Resistor 217 functions to simulate an unterminated bridge tap. Switch 243 of telephone load 126 controls whether to apply capacitor 233 to simulate an on-hook telephone condition or to apply resistor 218, capacitor 234, and resistor 219 to simulate an off-hook telephone condition. A

30   more detailed description of the operation of loads 122, 124, and 126 is left out

for the sake of brevity because one skilled in the art would understand the operation by looking at FIG. 2.

Simulation System – FIGS. 3-4

5   FIGS. 3-4 depict a specific example of a simulation system in accord with the present invention. Those skilled in the art will appreciate numerous variations from this example that do not depart from the scope of the invention. Those skilled in the art will also appreciate that various features described below could be combined with other embodiments to form multiple variations of the

10   invention. Those skilled in the art will appreciate that some conventional aspects of FIGS. 3-4 have been simplified or omitted for clarity.

FIG. 3 depicts a simulation system 302 in an example of the invention. Simulation system 302 is configured to communicate with a service provider communication link 305 of a service provider 304. Simulation system 302 is

15   comprised of a communication media simulator system 312. Communication media simulator system 312 is comprised of an interface system 322 and a tunable simulator system 324. In some examples, communication media simulator system 312 could be housed in an enclosure 319.

Interface system 322 is any system configured to communicate with a

20   service provider communication link. Tunable simulator system 324 is any system configured to receive a service provider signal, apply a load to the service provider signal to simulate a length of communication media, and vary the load to adjust the length of communication media simulated. A service provider is any system that provides communications. Some examples of

25   service providers are Internet Service Providers (ISP) and a central office of a phone company. A service provider communication link is any communication path to a service provider. A service provider signal is any signal used by a service provider for communications. One example of a service provider signal is a signal used for Digital Subscriber Line (DSL) service. A communication

30   media is any media that transfers a signal. Some examples of a communication media are wire, coaxial cable, and fiber.

FIG. 4 is a flow chart depicting a process 400 executed by simulation system 302 in an example of the invention. To start, interface system 322 communicates with service provider communication link 305. Tunable simulator system 324 receives a service provider signal through interface system 322.

5   Tunable simulator system 324 applies a first load to the service provider signal to simulate a length of communication media. Tunable simulator system 324 varies the first load to adjust the length of communication media simulated.

In some examples, simulation system 302 also includes a noise simulator system 313 in communication with communication media simulator system 312.

10   Those skilled in the art will appreciate that noise simulator system 313 could communicate with service provider communication link 305 directly or though intermediary devices. Noise simulator system 313 is any system configured to receive a service provider signal and apply a noise signal to the service provider signal to simulate noise interference. In operation, noise simulator system 313

15   receives the service provider signal. Noise simulator system 313 applies a noise signal to the service provider signal to simulate noise interference. Noise simulator system 313 varies the noise signal to adjust the noise interference simulated.

In some examples, simulation system 302 also includes a bridge tap

20   simulator system 314 in communication with communication media simulator system 312. Those skilled in the art will appreciate that bridge tap simulator system 314 could communicate with service provider communication link 305 directly or though intermediary devices. Bridge tap simulator system 314 is any system configured to receive a service provider signal, apply a load to the

25   service provider signal to simulate an unterminated bridge tap connected to a service provider, and vary the load to simulate a variable length of wire connected to the bridge tap. In operation, bridge tap simulator system 314 receives the service provider signal. Bridge tap simulator system 314 applies a second load to the service provider signal to simulate an unterminated bridge

30   tap. Bridge tap simulator system 314 varies the second load to simulate a variable length of wire connected to the bridge tap.

In some examples, simulation system 302 also includes an output system 316. Output system 316 could be connected to many test points in simulation system 302 and can vary depending on different implementations. Output system 316 determines simulation results by measuring signals at different

5   locations. Output system 316 then transmits the simulation results to a user interface. The user interface could be a display on output system 316, an auxiliary computer, or some other user interface.

In some examples, simulation system 302 also includes a control system 318 in communication with any of tunable simulator system 324, noise simulator system 313, and/or bridge tap simulation system 314. Control system 318

10   automatically adjusts tunable simulator system 324, noise simulator system 313, and/or bridge tap simulation system 314 to simulate certain conditions for a particular simulation. For instance, a user can pre-program control system 318 with a series of tests to run. Control system 318 tunes tunable simulator system

15   324 to simulate conditions for the tests. Control system 318 advantageously provides quick and accurate tuning of tunable simulator system 324, noise simulator system 313, and/or bridge tap simulation system 314.

The above-described operations of communication media simulator system 312, bridge tap simulator system 314, and noise simulator system 313

20   could be instructions that are executed by a processor and stored on storage media. As an example, the processor is connected to an analog-to-digital (A/D) converter. The A/D converter converts a service provider signal into a digital signal that the processor can process. The processor modifies the digital signal to simulate a load. The simulated load could be a length of communication

25   media, a device connected to a communication media, or some other device. The processor then transmits the modified digital signal to a digital-to-analog (D/A) converter. D/A converter converts the modified digital signal into an analog signal. The analog signal can then be used to simulate a condition to a service provider.

30   Some examples of instructions are software, program code, and firmware. Some examples of storage media are memory devices, tape, disks, integrated

circuits, and servers. The instructions are operational when executed by the processor to direct the processor to operate in accord with the invention. The term "processor" refers to a single processing device or a group of inter-operational processing devices. Some examples of processors are computers,

5 integrated circuits, firmware, and logic circuitry. Those skilled in the art are familiar with instructions, processors, and storage media.

Wire Line Simulator – FIG. 5

10 FIG. 5 depicts a specific example of a wire line simulator in accord with the present invention. Those skilled in the art will appreciate numerous variations from this example that do not depart from the scope of the invention. Those skilled in the art will also appreciate that various features described below could be combined with other embodiments to form multiple variations of the

15 invention. Those skilled in the art will appreciate that some conventional aspects of FIG. 5 have been simplified or omitted for clarity.

FIG. 5 depicts a wire line simulator 500 in an example of the invention. Wire line simulator 500 could be used by simulator system 302 in FIG. 3 as communication media simulator system 312. Wire line simulator 500 is

20 comprised of an interface 522, a tunable simulator 524, and a switch 526. Tunable simulator 524 is comprised of tunable resistors 531-532, tunable inductors 541-542, and a tunable capacitor 553. Tunable resistor 531 and tunable inductor 541 connect in series to a node 561. Tunable resistor 532 and tunable inductor 542 connect in series to a node 562. Tunable capacitor 553

25 connects in parallel to nodes 561 and 562. Nodes 561-562 are referred to in FIG. 5 by arrows for illustrative purposes and those skilled in the art will appreciate that nodes 561-562 are defined by Kirchhoff's Law.

Tunable resistors 531-532 are 5 – 1400 ohm variable resistors. Tunable inductors 541-542 are 0.01 – 3600 uH variable inductors. Tunable capacitor 553

30 is a 60 – 4200 pF variable capacitor. Switch 526 is a pushbutton two-circuit switch.

In operation, interface 522 connects tunable simulator 524 to a communication link 510 of a DSL service provider (not shown). Tunable simulator 524 receives DSL signals through interface 522. Tunable simulator 524 applies a load to the DSL signals to simulate a length of wire. Tunable simulator 524 simulates a local loop ranging from 250 feet to 16,500 feet. Tunable resistors 531-532, tunable inductors 541-542, and tunable capacitor 553 can be tuned to simulate different lengths of wire, different gauges of wire, and different temperatures. Switch 526 provides an interface to connect other simulator systems to wire line simulator 500. Connections 571 and 572 illustrate where bridge tap simulators, noise simulator simulators, or other simulators can be connected. A more detailed description of the operation of wire line simulator system 500 is left out for the sake of brevity because one skilled in the art would understand the operation without undue experimentation by looking at FIG. 5.

Bridge Tap Simulator – FIG. 6

FIG. 6 depicts a specific example of a bridge tap simulator in accord with the present invention. Those skilled in the art will appreciate numerous variations from this example that do not depart from the scope of the invention. Those skilled in the art will also appreciate that various features described below could be combined with other embodiments to form multiple variations of the invention. Those skilled in the art will appreciate that some conventional aspects of FIG. 6 have been simplified or omitted for clarity.

FIG. 6 depicts a bridge tap simulator 600 in an example of the invention. Bridge tap simulator 600 could be used by simulator system 302 in FIG. 3 as bridge tap simulator system 314.

Bridge tap simulator 600 is comprised of a bridge tap load 624. Bridge tap load 624 is comprised of a switch 626, tunable resistors 631-632, a resistor 633, tunable inductors 641-642, and a tunable capacitor 653. Tunable resistor 631 and tunable inductor 641 connect in series between nodes 661 and 662. Tunable resistor 632 and tunable inductor 642 connect in series between nodes 663 and 664. Resistor 663 connects nodes 661 and 663. Tunable capacitor

653 connects in parallel to nodes 662 and 664. Nodes 661-664 are referred to in FIG. 6 by arrows for illustrative purposes and those skilled in the art will appreciate that nodes 661-664 are defined by Kirchhoff's Law.

Tunable resistors 631-632 are 5 – 1400 ohm variable resistors. Tunable

5   inductors 641-642 are 0.01 – 3600 uH variable inductors. Tunable capacitor 653 is a 60 – 4200 pF variable capacitor. Resistor 633 is a 1 Mohm resistor. Switch 626 is a pushbutton two-circuit switch.

In operation, switch 626 of bridge tap load 624 controls whether to apply bridge tap load 624 to simulate an unterminated bridge tap condition. Resistor

10   633 functions to simulate the unterminated bridge tap condition. Tunable resistors 631-632, tunable inductors 641-642, and tunable capacitor 653 function to simulate a length of wire connected to a bridge tap. Tunable resistors 631-632, tunable inductors 641-642, and tunable capacitor 653 can be varied to adjust the length of wire connected to the bridge tap being simulated by bridge

15   tap load 624. A more detailed description of the operation of device simulator 600 is left out for the sake of brevity because one skilled in the art would understand the operation without undue experimentation by looking at FIG. 6.

Noise Simulator System – FIG. 7

20   FIG. 7 depicts a specific example of a noise simulator system in accord with the present invention. Those skilled in the art will appreciate numerous variations from this example that do not depart from the scope of the invention. Those skilled in the art will also appreciate that various features described below could be combined with other embodiments to form multiple variations of the

25   invention. Those skilled in the art will appreciate that some conventional aspects of FIG. 7 have been simplified or omitted for clarity.

FIG. 7 depicts a noise simulator system 700 in an example of the invention. Noise simulator system 700 could be used by simulator system 302 in FIG. 3 as noise simulator system 313. Noise simulator system 700 is comprised

30   of a signal generator 743, resistors 731-734, transformer 741, and a switch 726. Signal generator 743 connects to resister 731 in series. Resistor 731 connects

13